

**High Reliability
Power Supplies
PM44-56**

Instruction Manual





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High Reliability Power Supplies PM44-56

PM 51

Instruction Manual



ADVANCE
INDUSTRIAL
ELECTRONICS

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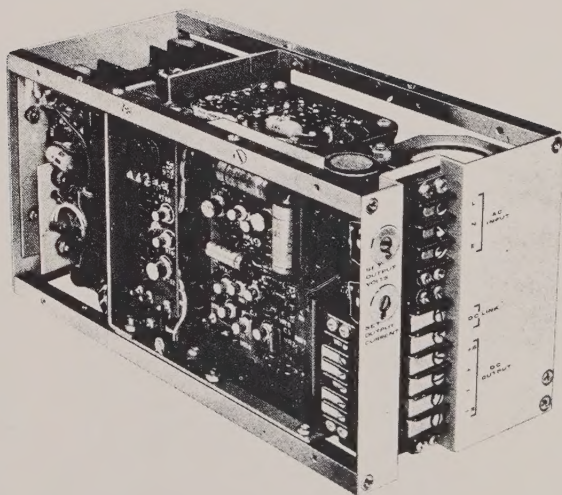


Fig. 1 Typical Modular Power Supply

This new range of Modular Power supplies, PM44-56, marks a radical departure from accepted attitudes in commercial power supply design.

The range provides pre-set output voltages in the range 0-50V in current ratings of 1, 3, 5, 10A and 20A with very extensive facilities and a high degree of reliability.

Facilities available include the selection of various output characteristics, such as constant current operation, by means of internal links, external programming and optional built in SCR overvoltage protection.

Particular emphasis has been placed on a high specification, rugged mechanical construction and long-life components. As a result of this attention it is possible to quote estimated MTBF figures for each individual unit.

- 10,000:1 Stability
- Re-entrant protection with constant current optional
- Programmeable on Voltage and Current
- MTBF estimated not less than 25,000 hours

Low Voltage Units for Integrated Circuits.

The range of Modular Power Supplies PM16-20 consists of units having a fully variable output of 0 to 7V with a choice of current ratings from 1 to 20A. They have been specifically designed to meet the requirements of Integrated Circuit Technology with particular reference to very high reliability, and incorporate a new protection circuit to safeguard both the power supply and the load. This range offers the Integrated Circuit user a power supply to satisfy most applications.

INPUT VOLTAGE

100, 105, 110, 115, 120, 125, 200, 220, 230, 240, 250V $\pm 10\%$ 48-450Hz

LINE REGULATION

Less than $\pm(0.001\% + 30\mu\text{V})$ for $\pm 10\%$ AC line variation at any specified tap.

LOAD REGULATION

Less than $(0.02\% + 1\text{mV})$ for a no load to full load swing

RIPPLE

Less than $400\mu\text{V}$ pk-pk, (typically 250μ pk-pk)

TEMPERATURE CO-EFFICIENT

Less than $(0.015\% + 200\mu\text{V})$ per $^{\circ}\text{C}$

OUTPUT IMPEDANCE

Less than 0.25Ω at 100kHz. Typically less than 0.1Ω at 100kHz.

RECOVERY TIME

For a full load step change the output voltage will recover in approximately 20μ seconds to within 10mV of regulation Band.

OVERLOAD PROTECTION

Re-entrant overload protection which is variable from 15% to 105% at full load current by a potentiometer on the front panel. At switch-on the protection may be set to operate at constant current for a period of 200m seconds after which it reverts to re-entrant operation. This facility is optional and may be selected by an internal link but is not available below 4 volts output.

OVERVOLTAGE PROTECTION

Optional

Overvoltage protection is by means of a high speed SCR crowbar with fuse. The trip voltage may be varied by potentiometer or programming resistors. This facility is an optional extra which can be built into the unit if required.

TEMPERATURE RANGE

-10° to $+60^{\circ}\text{C}$

INSULATION

Floating output must not exceed $\pm 250\text{V}$ DC from ground. Input tested 500V DC live to ground, and live to output greater than 10M ohms.

CONSTANT CURRENT OPERATION

Optional

All units can be operated in the constant current mode at reduced ratings. Further details can be found on Graph 2 Section 3 and Tables 5 to 7.

PROGRAMMING

External programming of both voltage and current by means of external resistors, is possible and is restricted to operation within the re-entrant characteristic, or within the constant current restrictions if operating in this mode. Further details of this form of operation can be found in Section 3.

PROGRAMMING RESISTANCES

VOLTAGE MODE $100\Omega/\text{volt} \pm \frac{1}{4}\%$

CURRENT MODE $100\Omega/100\%$ of output current $\pm 3\%$ for re-entrant current mode
 $1050\Omega/100\%$ of output current $\pm 3\%$ for constant current mode

OUTPUT VOLTAGES AND CURRENTS

Output Voltage	Output Current				
	1A	3A	5A	10A	20A
0-15V	PM44	PM47	PM50	PM53	PM56
0-30V	PM45	PM48	PM51	PM54	-
30-50V	PM46	PM49	PM52	PM55	-

Output Voltages factory pre-set in 1V increments and variable by $\pm 0.5\text{V}$ min by a potentiometer on the front panel.

FACTORY FITTED OPTIONS

Extra

SUFFIX 'X' Alternative PC board assembly to give $(0.005\% \pm 50\mu\text{V})/^{\circ}\text{C}$ temperature Co-efficient fitted instead

of standard $(.015\% + 200\mu V)/^{\circ}C$ temperature co-efficient.

SUFFIX 'Y' The Power Unit will be set to operate in constant current mode at the ratings in Tables 5, 6 and 7 instead of standard re-entrant mode.

SUFFIX 'Z' An SCR overvoltage protection circuit will be fitted within the Power Unit normally set to 10% or 1 volt (whichever is greater) above the nominal output voltage.

3.1 INSTALLATION

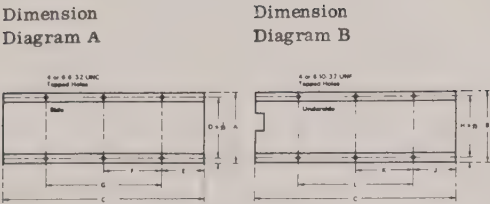


Fig. 2 Dimension Diagrams

Table 1 Fixing Centre Data, Dimensions, Weights and Dissipations

Overall Dimensions and Weights								
Type	Height		Width		Length		Weight	
	A in	cm	B in	cm	C in	cm	lb	kg
PM44	5 ¹ / ₈	13.0	3 ⁹ / ₃₂	8.3	5 ¹ / ₈	13.0	4	1.8
PM45	5 ¹ / ₈	13.0	4 ¹ / ₆₄	11.8	5 ¹ / ₈	13.0	6	2.7
PM46	5 ¹ / ₈	13.0	3 ⁹ / ₃₂	8.3	9 ¹ / ₄	23.5	8	3.6
PM47	5 ¹ / ₈	13.0	3 ⁹ / ₃₂	8.3	9 ¹ / ₄	23.5	8	3.6
PM48	5 ¹ / ₈	13.0	4 ¹ / ₆₄	11.8	9 ¹ / ₄	23.5	11	5.0
PM49	5 ¹ / ₈	13.0	7 ³ / ₈	18.7	9 ¹ / ₄	23.5	15	6.8
PM50	5 ¹ / ₈	13.0	4 ³ / ₆₄	11.8	9 ¹ / ₄	23.5	11	5.0
PM51	5 ¹ / ₈	13.0	7 ³ / ₈	18.7	9 ¹ / ₄	23.5	17	7.7
PM52	5 ¹ / ₈	13.0	4 ³ / ₆₄	11.8	15 ¹ / ₁₆	38.2	21	9.5
PM53	5 ¹ / ₈	13.0	7 ³ / ₈	18.7	9 ¹ / ₄	23.5	17	7.7
PM54	5 ¹ / ₈	13.0	7 ³ / ₈	18.7	15 ¹ / ₁₆	38.2	35	15.9
PM55	5 ¹ / ₈	13.0	9 ¹ / ₈	23.2	15 ¹ / ₁₆	38.2	44	20.0
PM56	5 ¹ / ₈	13.0	9 ¹ / ₈	23.2	15 ¹ / ₁₆	38.2	44	20.0

Table 1 Fixing Centre Data, Dimensions, Weights & Dissipations (Cont)

Fixing Centres								
Type	D		E		F		G	
	in	cm	in	cm	in	cm	in	cm
PM44	4 $\frac{3}{4}$	12.07	1	2.54	-	-	3 $\frac{1}{8}$	7.94
PM45	4 $\frac{3}{4}$	12.07	1	2.54	-	-	3 $\frac{1}{8}$	7.94
PM46	4 $\frac{3}{4}$	12.07	1	2.54	-	-	7 $\frac{1}{4}$	18.42
PM47	4 $\frac{3}{4}$	12.07	1	2.54	-	-	7 $\frac{1}{4}$	18.42
PM48	4 $\frac{3}{4}$	12.07	1	2.54	-	-	7 $\frac{1}{4}$	18.42
PM49	4 $\frac{3}{4}$	12.07	1	2.54	-	-	7 $\frac{1}{4}$	18.42
PM50	4 $\frac{3}{4}$	12.07	1	2.54	-	-	7 $\frac{1}{4}$	18.42
PM51	4 $\frac{3}{4}$	12.07	1	2.54	-	-	7 $\frac{1}{4}$	18.42
PM52	4 $\frac{3}{4}$	12.07	2 $\frac{1}{16}$	5.24	5 $\frac{15}{32}$	13.89	10 $\frac{15}{16}$	27.78
PM53	4 $\frac{3}{4}$	12.07	1	2.54	-	-	7 $\frac{1}{4}$	18.42
PM54	4 $\frac{3}{4}$	12.07	2 $\frac{1}{16}$	5.24	5 $\frac{15}{32}$	13.89	10 $\frac{15}{16}$	27.78
PM55	4 $\frac{3}{4}$	12.07	2 $\frac{1}{16}$	5.24	5 $\frac{15}{32}$	13.89	10 $\frac{15}{16}$	27.78
PM56	4 $\frac{3}{4}$	12.07	2 $\frac{1}{16}$	5.24	5 $\frac{15}{32}$	13.89	10 $\frac{15}{16}$	27.78
Type	H		J		K		L	
	in	cm	in	cm	in	cm	in	cm
PM44	2 $\frac{29}{32}$	7.39	1 $\frac{1}{2}$	3.81	-	-	2 $\frac{1}{8}$	5.40
PM45	4 $\frac{17}{64}$	10.85	1 $\frac{1}{2}$	3.81	-	-	2 $\frac{1}{8}$	5.40
PM46	2 $\frac{3}{32}$	7.39	2	5.08	-	-	5 $\frac{1}{4}$	13.3
PM47	2 $\frac{29}{32}$	7.39	2	5.08	-	-	5 $\frac{1}{4}$	13.3
PM48	4 $\frac{17}{64}$	10.85	2	5.08	-	-	5 $\frac{1}{4}$	13.3
PM49	7	17.78	2	5.08	-	-	5 $\frac{1}{4}$	13.3
PM50	4 $\frac{17}{64}$	10.85	2	5.08	-	-	5 $\frac{1}{4}$	13.3
PM51	7	17.78	2	5.08	-	-	5 $\frac{1}{4}$	13.3
PM52	4 $\frac{17}{64}$	10.85	3	7.62	5 $\frac{1}{16}$	12.86	9 $\frac{1}{16}$	23.02
PM53	7	17.78	2	5.08	-	-	5 $\frac{1}{4}$	13.3
PM54	7	17.78	3	7.62	5 $\frac{1}{16}$	12.86	9 $\frac{1}{16}$	23.02
PM55	8 $\frac{3}{4}$	22.23	3	7.62	5 $\frac{1}{16}$	12.86	9 $\frac{1}{16}$	23.02
PM56	8 $\frac{3}{4}$	22.23	3	7.62	5 $\frac{1}{16}$	12.86	9 $\frac{1}{16}$	23.02

Power Dissipations at Maximum Input Voltage

Unit	Max Full Load	Max Overload	Unit	Max Full Load	Max Overload
PM44	12W	13W	PM50	50W	60W
PM45	15W	20W	PM51	65W	105W
PM46	20W	33W	PM52	90W	155W
PM47	30W	35W	PM53	95W	130W
PM48	45W	60W	PM54	130W	200W
PM49	60W	95W	PM55	180W	310W
			PM56	190W	260W

3.2 AC SUPPLY

Verify that the connections to the primary of supply transformer T1 corresponds to the voltage of the local supply, and that the supply fuse FS1 is correct for the unit in use (see Table 4)

The primary connections of T1 should be paralleled when the local supply is 100 to 125V. Fig. 3 shows the connections for a 110V supply, and Table 2 gives the connections for supplies between 100 and 125V.

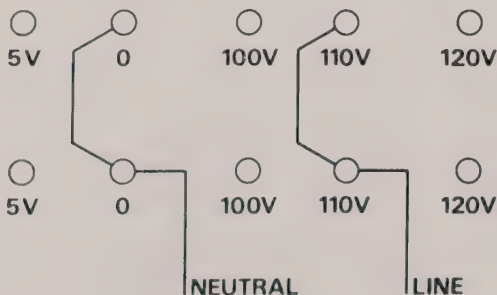


Fig. 3 Transformer Primary Connections for 110V

Table 2 Transformer Primary Connections 100-125V

Supply	Neutral	Line	Neutral Link Between	Line Link Between
100V	0	100	0-0	100-100
105V	5	100	5-5	100-100
110V	0	110	0-0	110-110
115V	5	110	5-5	110-110
120V	0	120	0-0	120-120
125V	5	120	5-5	120-120

When a 200 to 250V supply is available, the primary connections of T1 should be made in series. Fig. 4 shows the series connections to be made for a 240V supply, and Table 3 gives the connections for supplies between 200 and 250V.

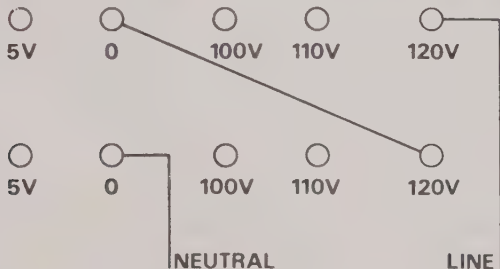


Fig. 4 Transformer Primary Connections for 240V

Table 3 Transformer Primary Connections 200-250V

Supply	Neutral to Inner Tag	Line to Outer Tag	Diagonal Link Between
200	0	100	0-100
210	5	100	5-100
220	0	110	0-110
230	5	110	5-110
240	0	120	0-120
250	5	120	5-120

Table 4 Fuse Rating (fuses up to 10A must be HRC type)

Power Supply	200-250V		FS1 100-125V		FS2 DC Fuse	
	Rating	Size	Rating	Size	Rating	Size
PM44	1A	00	2.5A	00	2.5A	00
PM45	2.5A	00	4A	00	2.5A	00
PM46	2.5A	00	4A	00	2.5A	00
PM47	2.5A	00	4A	00	4A	00
PM48	3A	0	7A	0	5A	0
PM49	5A	0	10A	0	7A	0
PM50	3A	0	7A	0	7A	0
PM51	5A	0	10A	0	7A	0
PM52	7A	0	15A	0	7A	0
PM53	5A	0	10A	0	12A	0
PM54	7A	0	15A	0	12A	0
PM55	10A	0	20A	0	12A	0
PM56	10A	0	20A	0	25A	*

*Fast Blow E E GS150 /25

3.2.1. PRELIMINARY CHECKS

Before the line supply is connected to the unit, ensure that the correct fuses are fitted as specified in Table 4. Check that the following terminal links on terminal block TB2 (mounted on the front panel) and TB3 (mounted on the left-hand side of the unit) are in position.

- (1) 1 and 2 on TB2 (DC LINK)
- (2) 3 (+s) to 4 on TB2)
- (3) 6 (-s) to 5 on TB2) DC output
- (4) 1 and 2 on TB3 (External programming of current)
- (5) 4 and 5 on TB3 (External programming of voltage)

NOTE If these links are not made the unit will not operate satisfactorily.

When the preliminary checks have been completed, connect the line supply to the following terminals on TB1.

Line	to 1
Neutral	to 2
Ground	to 3

3.3 RESETTING THE OUTPUT VOLTAGE**(a) SETTING THE OUTPUT VOLTAGE**

The unit is adjusted in the factory to provide the voltage indicated on the serial number panel, with a further $\pm 0.5V$ control available on the SET O/P VOLTS control positioned on the front panel. The following conditions should be observed.

- (1) The SET OUTPUT CURRENT control on the front panel should be fully clockwise.
- (2) The level of output voltage does not exceed the trip level of the overvoltage protection circuit (when fitted).

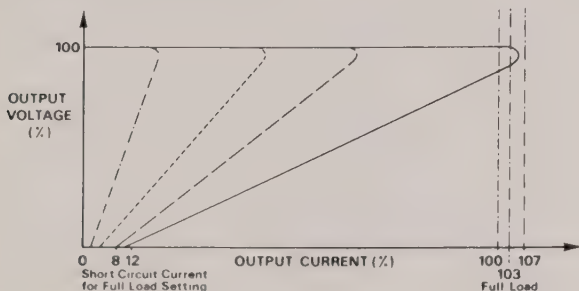
(b) TO CHANGE THE OUTPUT VOLTAGE

- (1) Connect a voltmeter across terminals 3(+s) and 5 (-s) on TB2.
- (2) Adjust the transformer taps on the secondary of T1 and R110, R111, R117, R118 and (R50 and R57 if fitted), as shown on tables 8, 9 and 10.
- (3) Switch on the AC Supply.
- (4) Adjust the SET OUTPUT VOLTS control to obtain the exact output level required.

(c) EXTERNAL PROGRAMMING OF OUTPUT VOLTAGE (see Section 3. 7)

3.4 RESETTING THE OVERLOAD PROTECTION

(a) The current re-entrant limit level is determined by the SET OUTPUT CURRENT control on the front panel. The control can be set to any value of current within the range 15% to 105% of the maximum rated current of the unit, provided that the correct value of R110 and R111 has been fitted.



Graph 1 Output Voltage Plotted Against Output Current

To set the output current rotate the SET OUTPUT CURRENT control fully clockwise. Switch on the AC supply.

Connect an ammeter and adjustable load between terminals 4 (+) and 5 (-) on TB2, and carefully adjust the load until the ammeter indicates the unit is delivering the required current.

Adjust the SET OUTPUT CURRENT control counter clockwise until the output voltage starts to fall, and then rotate the control a small amount clockwise.

Decrease the load resistance slowly and verify the maximum load current available.

NOTE As the output current setting is reduced so the maximum short circuit current is reduced proportionately, as shown on Graph 1.

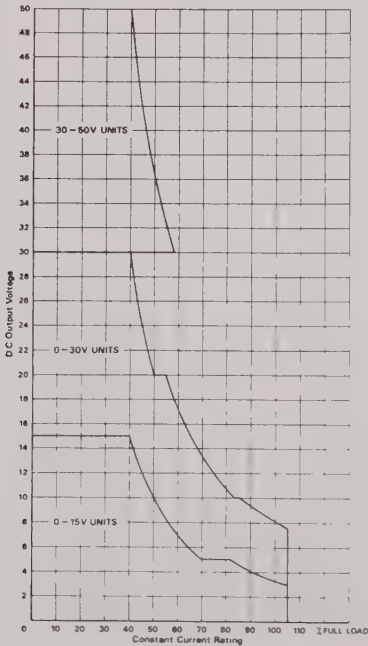
(b) TO OPERATE THE POWER SUPPLY IN CONSTANT CURRENT MODE

Remove the link between terminals 20 and 21, and 18 and 19 on the

AUX PC Board, and fit an external programming resistor between terminals 2 and 3 on TB3 having first removed the link between terminals 1 and 2. The maximum nominal currents allowable are shown on Tables 5, 6 and 7.

NOTE At no time must the current exceed the limit shown on Graph 2.

For currents other than those shown on Tables 5, 6 and 7 calculate programming resistor values as per specification, Section 2.



Graph 2 shows limits to output current in constant I mode

(c) CONSTANT CURRENT SWITCH ON

To remove the 200mS constant current switch on facility, remove the link between the terminals 20 and 21 on the AUX PC Board.

Table 5 Maximum Current in Constant Current Mode

With Output Volts set to	Nominal Output Current (Max)				
	PM44	PM47	PM50	PM53	PM56
1	1.0A	3.0A	5.0A	10A	20A
2	1.0	3.0	5.0	10	20
3	1.0	3.0	5.0	10	20
4	.83	2.9	4.1	8.3	16.6
5	.74	2.2	3.7	7.4	14.8
6	.62	1.9	3.1	6.2	12.4
7	.57	1.7	2.8	5.7	11.4
8	.54	1.6	2.7	5.4	10.8
9	.50	1.5	2.5	5.0	10.0
10	.48	1.4	2.4	4.8	9.6
11	.45	1.4	2.2	4.5	9.0
12	.42	1.3	2.1	4.2	8.4
13	.40	1.2	2.0	4.0	8.0
14	.39	1.2	1.9	3.9	7.8
15	.37	1.1	1.8	3.7	7.4

Table 6

With Output Volts set to	Nominal Output Current (Max)			
	PM45	PM48	PM51	PM54
1	1.0A	3.0A	5A	10A
2	1.0	3.0	5	10
3	1.0	3.0	5	10
4	1.0	3.0	5	10
5	1.0	3.0	5	10
6	1.0	3.0	5	10
7	1.0	3.0	5	10
8	.90	2.7	4.5	9
9	.82	2.5	4.1	8.2
10	.77	2.3	3.8	7.7
11	.72	2.2	3.6	7.2
12	.68	2.0	3.4	6.8
13	.65	1.9	3.2	6.5
14	.61	1.8	3.0	6.1
15	.58	1.7	2.9	5.8
16	.57	1.7	2.8	5.7
17	.55	1.6	2.7	5.5
18	.52	1.6	2.6	5.2
19	.51	1.5	2.5	5.1
20	.50	1.5	2.5	5.0
21	.47	1.4	2.3	4.7
22	.44	1.3	2.2	4.4
23	.43	1.3	2.1	4.3
24	.42	1.3	2.1	4.2
25	.40	1.2	2.0	4.0
26	.39	1.2	1.9	3.9
27	.38	1.1	1.9	3.8
28	.37	1.1	1.8	3.7
29	.36	1.1	1.8	3.6
30	.35	1.0	1.7	3.5

Table 7

With Output Volts set to	Nominal Output Current (Max)			
	PM46	PM49	PM52	PM55
30	.52A	.16A	2.6A	5.2A
31	.51	1.5	2.5	5.1
32	.50	1.5	2.5	5.0
33	.49	1.5	2.4	4.9
34	.48	1.4	2.4	4.8
35	.47	1.4	2.4	4.7
36	.46	1.4	2.3	4.6
37	.45	1.3	2.3	4.5
38	.44	1.3	2.2	4.4
39	.43	1.3	2.2	4.3
40	.42	1.3	2.1	4.2
41	.41	1.2	2.1	4.1
42	.40	1.2	2.0	4.0
43	.39	1.2	2.0	3.9
44	.38	1.1	1.9	3.8
45	.38	1.1	1.9	3.8
46	.37	1.1	1.9	3.7
47	.37	1.1	1.9	3.7
48	.36	1.1	1.8	3.6
49	.36	1.1	1.8	3.6
50	.35	1.0	1.8	3.5

3.5 RESETTING THE OVERVOLTAGE PROTECTION (IF FITTED)

- (1) Having checked that the overload protection is working, connect a voltmeter from terminal 4 (+) to terminal 5 (-) on TB2.
- (2) Set the overvoltage control (RV50) mounted on the Overvoltage Board to the maximum setting - fully clockwise.
- (3) Set the output voltage by rotating the SET OUTPUT VOLTS control RV101 or by using the external voltage programming facility to the required overvoltage level. (See external voltage programming, Section 3.7).
- (4) Slowly turn RV50 counter-clockwise until the overvoltage circuit operates. Operation is evident by a reduction to approximately 1V on the voltmeter.
- (5) Reduce the output voltage by varying the programming resistor to give approximately normal voltage.
- (6) Switch off the AC supply, and the switch on again, to reset the circuit.
- (7) Increase the output voltage by slowly increasing the programming resistor. This will check the operation of the circuit at the level indicated on the voltmeter.
- (8) Remove the External programming resistor.
- (9) Check the output voltage setting.

3.6 UNIT CONNECTIONS

Tables 8, 9 and 10 show the connections that should be made between the various secondary windings of T1 and the values of R110, R111, R117, R118 and (R50 and R57 if fitted), that should be inserted to obtain the required output voltage. These resistors are located on the AUX. PC Board and R50 and R57 on the O/V PC board.

NOTE When the overvoltage circuit is fitted it is necessary to change the link on the O/V PC board when operating units above 7V i.e.

0 - 7V LINK terminals 1 and 9

8 - 50V LINK terminals 1 and 8

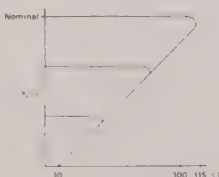
3.7 PROGRAMMING CURRENT AND VOLTAGE

Output Characteristics and Programming.

To enable users of these power supplies to have a wide range of operating conditions care has been taken in the design to accommodate facilities for modifying the basic operating characteristic. It will be appreciated that an alteration to the normal characteristic of the power unit must impose certain limits to its operating area.

3.7.1 EXTERNAL PROGRAMMING

Voltage, current and overvoltage protection levels can be controlled externally. To utilise the facility it is necessary to remove terminal links (which disconnect the internal controls from circuit) and connect external resistors by means of remote lines if necessary. By using resistors whose values correspond to the voltage or current required, voltage control, current control and overvoltage control can be effected remotely.



Graph 3

NOTE If remote lines are used, their resistance is to be included in the value of the programming resistor and they should be shielded from stray electromagnetic fields to minimise 'noise' pick-up.

3.7.1 (a) VOLTAGE CONTROL

For external control of voltage, RV101 is disconnected from circuit and replaced by an external potentiometer or fixed resistor. The level of the output voltage is related to the value of the external resistance by the 100Ω V scale factor for all units.

NOTE When the voltage is reduced from the set MAX the MAX current setting is also reduced if re-entrant current mode protection is in use. See Graph 3.

To connect the unit for external programming of voltage the procedure is as follows:-

- (1) Switch off AC supply.
- (2) Disconnect the link across terminals 4 and 5 of TB3
- (3) Connect the external programme resistor to terminal 4 of TB3 and terminal 6 of TB2. (-ve SENSE).
- (4) Switch on the AC supply.

3.7.1 (b) CURRENT CONTROL

For external control of current, RV100 is disconnected from circuit and replaced by an external potentiometer or fixed resistor. The level of current is related to the value of the external resistance by the Ω/A scale factor which is given in Section 2 for each of the power supplies. To connect the unit for external programming of current, the procedure is as follows:-

- (1) Switch off the AC supply.
- (2) Disconnect the link across terminals 1 and 2 of TB3.
- (3) Connect the external programme resistor to terminals 3 and 2 of TB3.
- (4) Switch on the AC supply.

3.7.1 (c) OVERVOLTAGE CONTROL

For external control of the overvoltage protection circuit, RV50 is disconnected from circuit and replaced by an external potentiometer or resistors. A resistance range from 0 to $3.3K\Omega$ corresponds approximately to an overvoltage protection range of

- 1.5V to 120% of FULL OUTPUT VOLTAGE FOR 0 -15V UNITS
- 3V to 120% of FULL OUTPUT VOLTAGE FOR 0 -30V UNITS
- 5V to 120% of FULL OUTPUT VOLTAGE FOR 30-50V UNITS

To connect the unit for external programming of overvoltage protection, the procedure is as follows:-

- (1) Switch off the AC supply.
- (2) Disconnect the link across terminals 4 and 5 on the overvoltage printed circuit board.
- (3) Connect an external programme potentiometer of $3.3K$ resistance to terminals 4 (slider), 6 and 7 of the printed circuit board connector. Alternatively connect fixed resistors between terminals 7 and 4 and between terminals 6 and 4.
- (4) Switch on the AC supply.
- (5) Adjust for overvoltage setting.

3.8 PARALLEL AND SERIES OPERATION

3.8.1. Up to a maximum of 5 modular power units can be operated in parallel, (or 3, 20A units) and should be connected as shown in Fig. 5. For best voltage regulation, the terminal labelled 'P' on the circuit, (terminal 6 of TB3) on each unit should be returned to a common point, and four-terminal sensing used as described in Section 3.10 - but this is not essential.

NOTE When units are connected in parallel the built-in thyristor of the optional overvoltage circuit in each unit must be made inoperative, because it is not possible to ensure that each thyristor will have an equal share of total current under fault condition unless connected as shown in Fig. 6. This is done by removing the gate connection of the thyristor either at the thyristor itself, or at the overvoltage PC board (terminal 3).

If overvoltage protection is required, an external thyristor of suitable rating for the total parallel current of all units should be used. Its gate terminal should be connected to pin 3 on the overvoltage board of one unit after disconnecting the existing gate connection to MR102. A gate firing current of approximately 50mA is available from pin 3. The cathode should be connected to the common negative line and the anode to the common positive line. Set overvoltage as in section 3.5 All other units should have gate connections to pin 3 removed as outlined above.

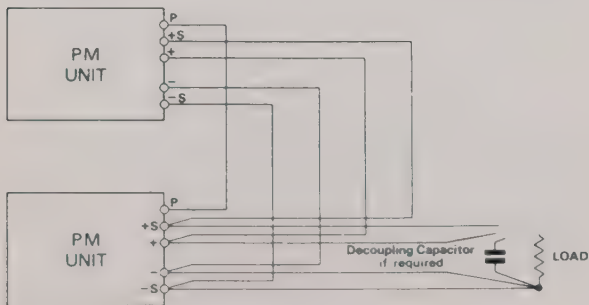


Fig. 5 Parallel Operations

3.8.2. PARALLEL OPERATION WITH BUILT IN THYRISTORS MR102.

Units should be connected as shown in Fig. 6 under the conditions as follows:

- (a) If necessary each unit is to be set up separately to the required operating conditions as detailed in paragraphs 3.4 and 3.5.
- (b) A diode of the same current and voltage rating as the power module, must be connected in series with each output (positive end of the diode to negative terminal of power module.)
- (c) Link the 'P' terminals 6 on TB3.
- (d) Link the sensing terminal as shown in Fig. 6.

NOTE Because the forward voltage drop of the diode uses all the allowable external lead voltage drop no extra lead length can be allowed for four terminal sensing.

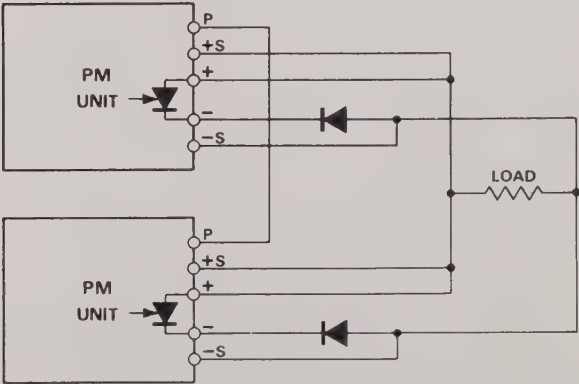


Fig. 6 Parallel Units with Overvoltage Circuits Fitted.

NOTE R106 must be removed from between terminals -ve and -ve sense.

3.8.3 It is also possible to operate modular power units in series under certain conditions as follows:-

- (a) If necessary, each unit is to be set up separately to the required operating conditions as detailed in paragraphs 3.4 and 3.5
- (b) A diode, of the same current and voltage rating as the power module, must be connected across EACH power module output (positive end of diode to positive terminal of power module).
- (c) The number of modules connected in series is limited to give a maximum of 250V DC.

3.9 OPERATION WITH OTHER POWER SUPPLY UNITS

When power modules are used in conjunction with other power supplies of opposite polarity, provision must be made as in 3.8.3(b) to protect the power module against reverse voltage conditions. The rating of the diode used must be sufficient to carry the fault current generated.

3.10 FOUR-TERMINAL SENSING

Where long external output leads are used, four-terminal sensing is provided to enable the load voltage regulation of the power supply to be maintained at the load connections. The two links between the +ve output and the +ve sense, and the -ve output and the -ve sense terminals should be removed and connections made as shown in Fig. 7. These output connections should be run together and a decoupling capacitor, similar to C102 in the power supply, connected at the load terminals if the high frequency output impedance is to be maintained. Parallel connection should be made as shown in Fig. 8.

The maximum permissible voltage drop in the external leads when using four-terminal sensing is 0.5V total in both leads i.e. 0.25V in each lead +ve and -ve or 0.5V in one supply lead with a ground return of negligible resistance. The total permissible length of lead for 0.5V drop is listed in Table 11 for various wire sizes and current ratings. Note that this is the total permissible loop length 'go and return' and that the power supply can only be situated at half this distance from the load for a two wire +ve and -ve lead system.

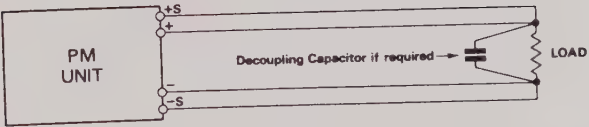


Fig. 7 Four-terminal Sensing

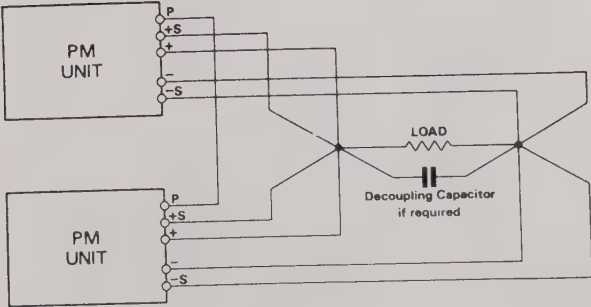


Fig. 8 Four-terminal Sensing (Parallel)

Table 9 Voltage Adjustments PM45, 48, 51, 54.

CONNECTIONS						RESISTOR VALUES						
Volts out	Rec (1)	Transformer				Rec (2)	R110	R111	R117	R118	R50	R57
		17 - +	9 - +	3 - +	1 - +							
1						22Ω	22Ω	LINK	Not used up to 15V	470Ω	91Ω	
2						150Ω	12Ω	100Ω		470Ω	91Ω	
3						270Ω	22Ω	220Ω		470Ω	91Ω	
4						390Ω	33Ω	300Ω		470Ω	91Ω	
5						560Ω	LINK	390Ω		470Ω	91Ω	
6						680Ω	LINK	470Ω		470Ω	91Ω	
7						820Ω	LINK	560Ω		470Ω	91Ω	
8						910Ω	LINK	680Ω		120Ω	51Ω	
9						910Ω	180Ω	820Ω		120Ω	51Ω	
10						1.2K	LINK	910Ω		120Ω	51Ω	
11						1.2K	150Ω	1K		470Ω	51Ω	
12						1.2K	270Ω	1.1K		470Ω	51Ω	
13						1.5K	100Ω	1.2K		470Ω	51Ω	
14						1.5K	270Ω	1.3K		470Ω	150Ω	
15						1.8K	47Ω	1.4K		470Ω	150Ω	
16						1.8K	180Ω	1.5K	47K	470Ω	150Ω	
17						1.8K	330Ω	1.8K	12K	470Ω	150Ω	
18						1.8K	470Ω	1.8K	22K	470Ω	150Ω	
19						2.2K	180Ω	1.8K	68K	470Ω	220Ω	
20						2.2K	330Ω	2.0K	27K	470Ω	220Ω	
21						2.2K	430Ω	2.0K	82K	1.5K	220Ω	
22						2.2K	560Ω	2.2K	33K	1.5K	220Ω	
23						2.7K	220Ω	2.2K	100K	1.5K	220Ω	
24						2.7K	330Ω	2.4K	33K	1.5K	220Ω	
25						3.0K	180Ω	2.4K	100K	1.5K	330Ω	
26						3.3K	LINK	2.7K	27K	1.5K	330Ω	
27						3.3K	120Ω	2.7K	47K	1.5K	330Ω	
28						3.3K	270Ω	2.7K	120K	1.5K	330Ω	
29						3.3K	390Ω	3K	33K	1.5K	330Ω	
30						3.3K	510Ω	3K	56K	1.5K	330Ω	

NOTE

Resistor Types
R110 R111

Electrosil TR5+2%

R117	CGS CR1.5 up to 5V $\pm 5\%$ 6V to 30V $\pm 2\%$
R118	Electrosil TR5 $\pm 5\%$
R50	Electrosil TR5 $\pm 5\%$
R57	Up to 18V Electrosil TR5 $\pm 5\%$ 19-30V Welwyn W21 $\pm 5\%$

Table 10 Voltage Adjustments PM46, 49, 52, 55.

CONNECTIONS							RESISTOR VALUES					
Volts out	Rec (1)	Transformer				Rec (2)	R110	R111	R117	R118	R50	R57
		40 - +	6 - +	3 - +	1 - +							
30						3.3K	510	3K	56K	1.5K	330	
31						3.6K	230	3K	160K	2.7K	390	
32						3.6K	470	3.3K	39K	2.7K	390	
33						3.6K	620	3.3K	68K	2.7K	470	
34						3.9K	470	3.3K	220K	2.7K	470	
35						3.9K	560	3.6K	47K	2.7K	470	
36						2.4K	1.2K	3.6K	82K	2.7K	470	
37						2.7K	2.0K	3.6K	220K	2.7K	470	
38						2.7K	2.2K	3.9K	56K	2.7K	560	
39						3.0K	2.0K	3.9K	91K	3.3K	560	
40						3.3K	1.8K	3.9K	330K	3.3K	560	
41						3.3K	2.0K	4.3K	47K	3.3K	560	
42						3.6K	1.8K	4.3K	68K	3.3K	560	
43						3.3K	2.2K	4.3K	120K	3.3K	560	
44						3.6K	2.0K	4.3K	330K	3.9K	560	
45						3.6K	2.2K	4.35K	Not used	3.9K	680	
46						3.9K	2.0K	4.45K		3.9K	680	
47						4.3K	1.8K	4.55K		3.9K	680	
48						4.7K	1.5K	4.65K		4.3K	680	
49						4.3K	2.0K	4.75K		4.3K	680	
50						4.3K	2.2K	4.85K		4.3K	680	

NOTE Resistors Types

R110 R111	Electrosil TR5 $\pm 2\%$
R117	CGS CR1.5 30 and 31V $\pm 2\%$ 32V to 50V $\pm 1\%$
R118	Electrosil TR5 $\pm 5\%$
R50	Electrosil TR5 $\pm 5\%$
R57	30-32V Welwyn W21 $\pm 5\%$ 33-50V RVW4-J $\pm 5\%$

Table 11 Permissible lead length for four-terminal sensings.

Wire	Lead Length (feet and metres)									
Size	PM44, 45		PM47, 48		PM50, 51		PM53, 54		PM56	
	46		49		52		55			
	ft	m	ft	m	ft	m	ft	m	ft	m
7/0076	19	6								
14/0076	38	12	13	4						
23/0076	60	18	20	6	12	3.5				
40/0076			68	21	21	6.5	10	3		
70/0076					37	11	18	5.5	9	2.7
110/0076					58	18	29	9	14	4.5
162/0076							43	13	21	6.5

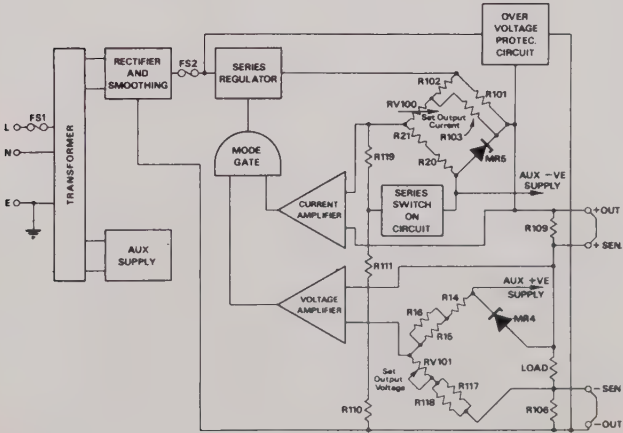


Fig. 9 Functional Diagram of Power Unit

4.1 GENERAL

A simplified functional diagram of the circuitry of the power unit is shown in Fig. 9. The voltage and current modes of operation are controlled by two independent bridge circuits. Any variation of load current or output voltage produces an out-of-balance condition of the associated bridge. The output of the bridge is applied to a comparator amplifier whose output is fed into a mode gate. The output of the mode gate controls the output resistance of a series regulator which (assuming the initial variation was within the present operating limits of the unit) restores the original mode conditions.

The circuit cannot operate in both modes simultaneously, and only the control signal from the bridge corresponding to the mode of operation passes through the gate. Crossover from one mode to another is automatic, and the point of crossover is determined by the settings of the two controls SET OUTPUT VOLTS (RV101) and SET OUTPUT CURRENT (RV100).

An auxiliary stabilised power supply is also incorporated. This supplies the bridge circuits and the comparator amplifiers; to simplify the functional diagram, the output connections of the auxiliary supply are not shown. Overvoltage protection is afforded by a sensing circuit connected across the stabilised output terminals. The level at which the circuit operates is controlled by the setting of a potentiometer.

4.2 SUPPLY RECTIFICATION AND SMOOTHING

The AC input voltage within the range 100V-125V and 200V-250V, 48Hz to 450Hz is applied, via the terminals of TB1, to the primary of T1. Interconnection of the primary terminals for different voltage supplies is given in Section 3.2.

The transformer has five secondary windings. The output voltage derived from one winding is used for the auxiliary supply. This AC voltage is full-wave rectified by MR1 and MR2 and smoothed by R1, C1 and C2. The output voltage of the other windings connected as per Section 3.6 is applied to the bridge rectifier MR100 and then smoothed by C101. The resultant 'raw' DC is protected by fuse FS2 and then applied to the series regulator.

4.3 SERIES REGULATOR

The series regulator contains transistor VT100 and transistor VT101 (which may consist of several transistors in parallel) arranged in a Darlington-pair configuration. An increasing positive signal applied to the base of VT100 decreases the output resistance of the circuit; conversely, a decreasing signal increases the output resistance. Each transistor in VT101 has a separate resistor in the emitter circuit to provide current sharing between transistors. The voltage developed by the flow of load current through the resistor R101 is connected across a common potential divider network of resistor R102 and R103 to provide a voltage signal proportional to the output current which is standardised at 0.85V for 100% output current.

4.4 BRIDGE REFERENCE SOURCES

Two zener diodes, MR4 and MR5, are used as reference sources in the voltage and current bridges, respectively.

These diodes are connected in series with the resistor network of R10, R11 and R12 across the auxiliary voltage supply line, and MR4 is also used as the reference for the stabilising circuitry of the auxiliary voltage supply. The flow of current through the two diodes is determined by accurate adjustment of the value of the resistor network. This level of current is maintained by the stabilised auxiliary voltage.

4.5 STABILISATION OF THE AUXILIARY SUPPLY

Stabilisation is effected by the sensing network R5, R6 and R9 and the associated circuitry of the transistors VT1 to VT4. A proportion of any change in the auxiliary voltage is fed to the base of VT3 which is in a long-tail pair configuration with VT4. Assume that the voltage across the sensing network tends to rise. An increase in the voltage drop across R6 occurs. This increases the base voltage of VT3 which is compared with the fixed base voltage of VT4 established by MR4. The resultant positive increase of the collector potential of VT4 decreases the conduction of VT2: the emitter voltage of VT2 is fixed by Zener diode MR3. As a result, the decreased conduction of VT2 reduces the base drive of the series regulator transistor VT1. Thus, the resistance of VT1 increases and counteracts the initial tendency of the output voltage to rise. Resistor R4 ensures initial conduction of VT1.

4.6 VOLTAGE CONTROL BRIDGE

The circuitry which senses any tendency of the output voltage to change is shown in a bridge configuration in Fig. 9 and the Circuit Diagram Fig. 12. Any unbalance of the bridge is detected by the long-tail pair VT5 and VT6 which operate as the voltage comparator amplifier. The two diodes, MR6 and MR7, connected from the base of VT5 to the base of VT6 protect the two transistors against heavy discharge current from C102 if the capacitor is in a charged condition when the sense lines are connected.

As shown in Fig. 9 the resistor network R14, R15, and R16 and RV101, R117 and R118 form two arms of the voltage control bridge. When the bridge is balanced, the voltage condition is as follows:-

$$V_{MR4} = V_{(R14+R15/R16)}$$

$$V_{(RV101+R117/R118)} = V_{OUT}$$

For V_{OUT} to equal $(RV101 + R117/R118)$ at all settings of RV101, R117 and R118, the output voltage must be a direct function of the resistance of RV101, R117 and R118.

4.7 VOLTAGE CONTROL

With the bridge balanced, the circuit will remain in equilibrium until the output voltage tends to change. Any change in output voltage across the load is fed back, via the positive sense line to the base of VT6 where it is compared with the base voltage of VT5. The resultant change of level of the collector voltage of VT5 is applied to MR8 which with MR9 forms the mode gate. A change in signal to MR8 results in a change of output resistance of the series regulator in such a direction as to counteract the original change in voltage.

4.8 CURRENT CONTROL BRIDGE

The circuitry forms a bridge configuration as shown in Fig. 10 and the Circuit Diagram Fig. 12.

The output current in passing through the R101's in parallel provides a voltage signal proportional to the output current which is divided down to a standard level by resistors R102 and

R103 in parallel with R104. This signal is compared with the voltage generated across RV101 by the current i_1 (which is the sum of currents i_2 and i_3) by the long-tail pair VT7 and VT8 operating as a comparator amplifier.

When the power unit is operating in the current mode the voltage amplifier is inoperative and the current bridge is in a balanced condition. The voltage conditions are then as follows:-

$$I_{OUT} \times R101 \left[\frac{R103/R104}{R102 + R103/R104} \right] = i_1 \times RV100$$

i.e. $I_{OUT} = K \times i_1 \times RV100$

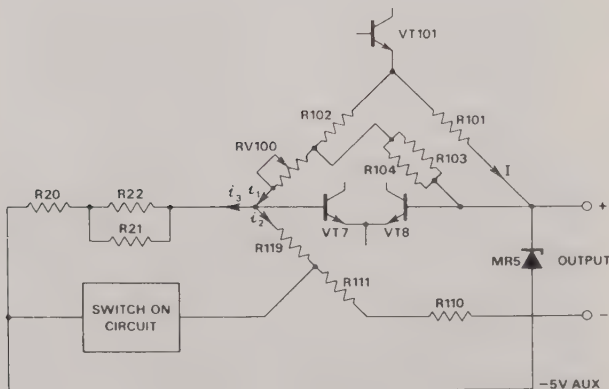


Fig. 10 Current Control Circuit

4.8.1 RE-ENTRANT CURRENT MODE

i_3 is supplied from the -ve auxiliary supply (MR5) via R20, R21 and R22 and therefore is essentially constant under all output voltage conditions. i_2 is supplied from the -ve output line via R119, R111 and R110 and is therefore proportional to output voltage.

As the load resistance changes from a high value R_{CV} through the critical value R_C (where the power unit changes from voltage controlled to current controlled operation) to a low value R_{CR} the output current falls at the same time as the output voltage falls as shown in Fig. 11.

At the limit, i.e. short circuit load

$$V_{OUT} = 0$$

$$\text{hence } i_2 = 0$$

and therefore

$$i_1 = i_3$$

and therefore for balance

$$I_{OUT} = K \times i_3 \times RV100$$

i_3 therefore sets the maximum short circuit current from the unit.

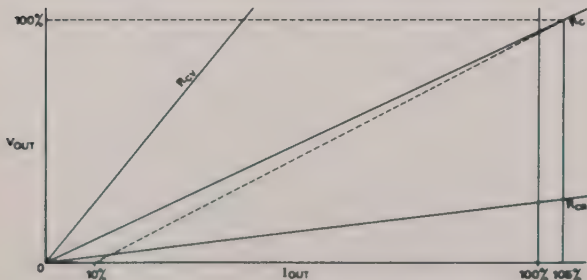


Fig. 11 Output Voltage plotted against Output Current in Re-Entrant Mode

4.8.2 CONSTANT CURRENT MODE

In the constant current mode i_2 is disconnected and the output current is therefore proportional to i_3 only and is therefore essentially not affected by the output voltage.

4.8.3 SERIES SWITCH-ON CIRCUIT

Due to the re-entrant circuit protection it is not possible to connect two or more power supplies in series with a common load current. It has therefore been necessary to modify the characteristic at switch on so that for approximately 200mS the supply will go into a constant current mode, this being the time the supplies take to stabilise their voltages.

At switch on the output voltage is zero, and hence without the switch-on circuit

$$\begin{aligned} i_1 &= i_3 \\ \text{and therefore } i_{OUT} &= K \times i_3 \times RV100 \\ &= 10\% \text{ of output current} \end{aligned}$$

To overcome this problem the current i_2 is provided via the switch-on circuit for the first 200mSec.

Now as C103 is charging at switch on VT102 is biased on, hence R119 is connected via VT102 to MR101 which in conjunction with MR5 forms a -2V supply. Hence R119 has the same i_2 flowing as if the output voltage was stabilised at full output, and hence the current will be held constant at I_{max} for APP. 200mS the charging time of C103, R114.

VT102 is biased off when C103 has charged and has no further part in the circuit.

4.9 CURRENT CONTROL

With the bridge balanced, the circuit will remain in equilibrium until the output current tends to change. Any change of load current changes the voltage drop across resistors R103, R104 with respect to the base of VT8. A proportion of this voltage change is applied, via RV100 to the base of VT7. The resultant change in the level of the collector voltage of VT8 is then applied. MR9 which with MR8 forms the mode gate. A change in signal to MR9 results in a change of output resistance of the series regulator in such a

direction as to counteract the original change in current

4.10 MODE OF OPERATION

The mode of operation of the power supply is determined by the load conditions and the setting of the voltage and current controls. Automatic crossover from one mode to the other is depicted in Fig. 11 and occurs at the value of load resistor designated R_C . The value (in ohms) of the load resistor R_C is obtained by dividing the voltage (volts) set by RV101, R117 and R118 and the current (amps) set by RV100. When the power supply is connected to any load R_{CV} whose resistance is more than R_C the mode of operation is constant voltage. When the resistance of the load decreases to any value R_{CR} below R_C the mode of operation is re-entrant or constant current.

During either mode of operation, both comparator amplifiers produce output voltages which are applied to two diodes in the mode gate. Diode MR8 is controlled by the output of the voltage comparator (collector of VT5), and diode MR9 is controlled by the output of the current comparator (collector of VT8). The diode which conducts is the one receiving the higher output voltage. The output from the conducting diode is amplified by VT9 and then applied, via the emitter-follower VT10, to the series regulator. Except for a brief transitional period at crossover, both diodes do not conduct simultaneously; thus, it is always the higher output of the two comparators which controls the resistance of the series regulator.

NOTE that VT9 introduces polarity inversion, and a high positive output from the mode gate produces high resistance of the series regulator.

The crossover action is best understood by considering the operation of the control circuits as the resistance of the load is decreased from a high value of R_{CV} to a low value below R_C . At first, with a very low load current flowing, the collector voltage of VT8 is very low because the voltage developed across R103, R104 is low, and the resultant low base voltage of VT7 allows VT8 to conduct heavily. At the same time, the collector voltage of VT6 is high because with low load current the stabilised output voltage tends to rise, but is held at its predetermined level by heavy conduction of VT6 which results in a high positive potential at the collector of VT5. Thus, of the two signals applied to the mode

gate, the signal from VT5 will take control and effect the high value of output resistance required of the series regulator.

As the resistance of the load is decreased, VT7 senses the increased voltage drop across R103, R104 and increases conduction. This decreases the conduction of VT8 and its collector potential rises. Simultaneously, the collector voltage of VT5 decreases in order to reduce the output resistance of the series regulator so that the higher load current may flow.

This action of the collector voltage of VT8 rising and that of VT5 falling as the resistance of the load decreases continues until at the crossover point the signal from VT8 takes control and a rapid transition from voltage mode to current mode occurs. The output supply voltage of the unit then falls to the level required to sustain the preset current level. This rapid transition from voltage mode to current mode provides overcurrent protection.

4.11 OVERVOLTAGE PROTECTION

The overvoltage protection circuit uses a long-tail pair comparator circuit containing transistors VT50 and VT51. The input to the base of VT51 is derived from R55 which with R54 forms a potential divider across the stabilised output supply. VT51 base voltage is compared with the base voltage of VT50 derived from the potentiometer RV50 connected across a Zener diode reference source MR50. The level at which overvoltage protection is required is effected by the setting of RV50; because this level is obviously above the stabilised output voltage, the normal quiescent condition of the long-tail pair is such that VT50 is conducting much more than VT51. In practice, the overvoltage limit is set approximately 10% above the level of the stabilised voltage. If the stabilised output voltage rises above the level set by RV101, transistor VT51 conducts and drives VT52 into heavy conduction. The base voltage of VT52 is fixed by the Zener diode MR51; consequently, VT52 provides a constant current via R57 to the gate electrode of SCR MR102 which fires and produces a short circuit across the terminals of the stabilised output supply.

4.12 EXTERNAL PROGRAMMING

As explained during the description of the voltage and current control bridges, the balance conditions of the bridges are such that the following conditions exist,

- (1) The voltage across the resistance of RV101 (SET OUTPUT VOLTS) is equal to the output voltage. A change of resistance of RV101 produces a directly proportional change of output voltage.
- (2) The voltage across the resistance of RV100 (SET OUTPUT CURRENT) is equal to the voltage across resistors R103, R104 which, in turn, is directly proportional to output current. A change of resistance of RV100 produces a directly proportional change of output current.

Thus, resistance-output voltage and resistance-output current relationships exist, and these are expressed as Ω/V and Ω/A scale factors, respectively. By disconnecting the variable resistors from circuit and in their place connecting - by remote lines if necessary - fixed or variable resistors, the output voltage or current level can be set by altering the value of resistance. The advantage of this circuit facility is that without any monitoring or metering aid, the voltage and current level can be set simply by the value of resistance in circuit. The method of connecting the unit for external programming of output voltage, output current and overvoltage protection is detailed in Section 3.

5.1 ACCESS TO COMPONENTS

All components, except those mounted on the printed circuit boards, are accessible after removing the front panel (held by fixing screws) and detaching the heat sink assemblies from the side bars. Access to the components on the printed circuit board during operating conditions may be obtained by removing the board and connecting it to the socket in the unit via an extension board (Advance Part No. 19014).

NOTE The printed circuit boards must not be removed from the modules without first switching off the AC supply.

5.2 REPLACEMENT SERVICING OF PRINTED CIRCUIT BOARDS

The control boards used in any of the units in the PM44-56 range are interchangeable. The Overvoltage Boards, if fitted in the units, are also interchangeable.

The extension board is available as a servicing aid. This board can be used as an extended connector for any printed circuit board in the entire range PM44-56 of modular Stabilised Power Supplies.

All boards are available as spare parts, and the following Advance Part No. should be quoted when ordering.

- | | |
|---------------------|------------------------|
| (1) Control Board | Advance Part No. 26521 |
| (2) Extension Board | Advance Part No. 19014 |

5.3 FAULT FINDING

Determine the state of the output voltage ON LOAD and proceed as outlined in Table 12.

Table 12. Fault Finding Chart

Output Voltage	Fault	Action
No Output	Input Fuse blown MR100 open circuit FS1 blown AND OR FS2	Change fuse. Change MR100 Change fuse. Check circuit for cause. VT1 may be short circuit.
	DC LINK OPEN CCT	Refit

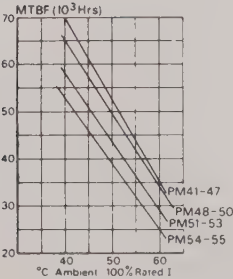
Table 12 Fault Finding Chart (Cont)

Output Voltage	Fault	Action
Low Output	VT101 open circuit	Change VT101.
	RV100 fully anti clock	Re. Adj.
	Printed circuit board out of socket or faulty	Replace with new assembly.
	MR100 partially open circuit	Change MR100
	MR102 has fired (if fitted)	Check external circuit for overvoltage.
	RV100 Set Low	Readjust
	Re-entrant Links o/c	Replace
High unstabilised output)	Printed circuit board faulty	Replace with new assembly.
	) VT100 short circuit	Change VT100
	) VT101 short circuit	Change VT101
	) Printed circuit board faulty	Replace with new assembly. Check to see why MR102 has not fired. If fitted.
High Ripple	)	
Excessive Output Current	)	
	)	
	)	
	)	
	)	
	Programming link TB3 (2 & 3) o/c	Replace
	Programming link Resistor o/c	Replace
	Re-entrant links in for constant current operation	

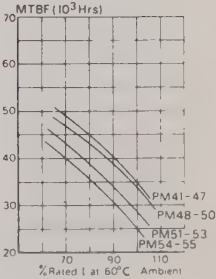
5.4 MEAN TIME BETWEEN FAILURES

The figures quoted below are estimated from data currently available from international sources. These estimates are based on continuous operation at maximum temperature, output voltage and current, and will improve appreciably if units are operated in less arduous conditions. An indication of the possible improvement can be obtained from the accompanying graphs.

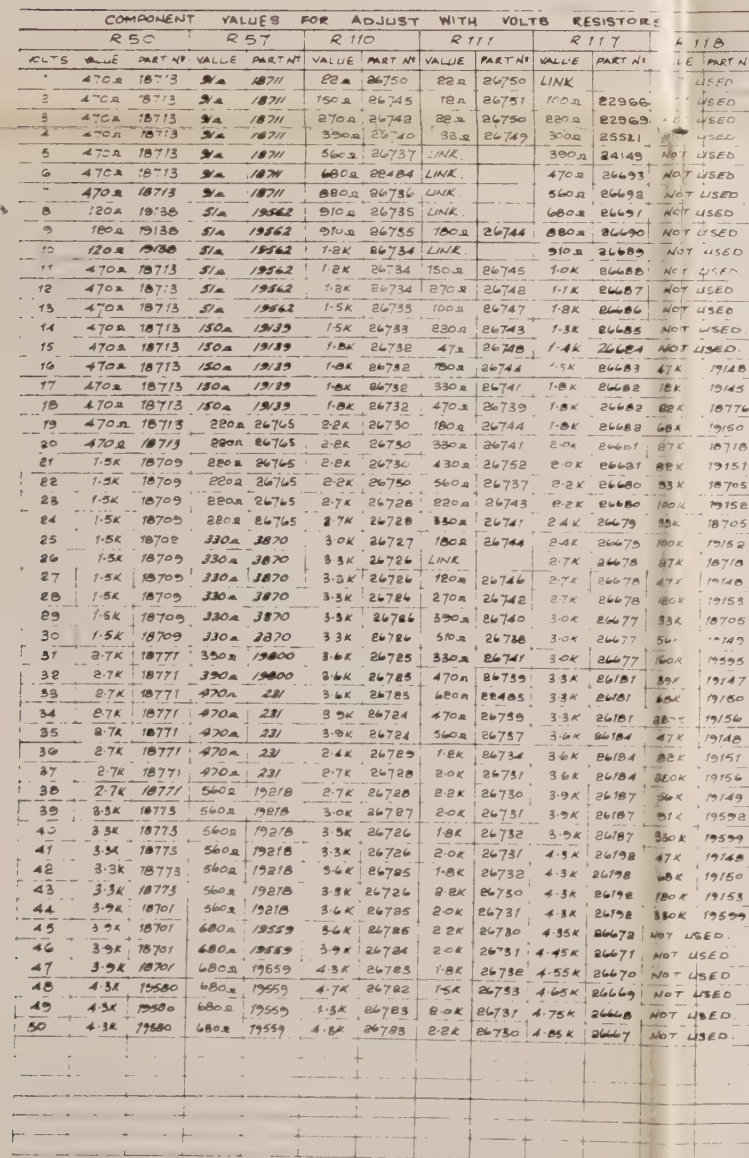
Unit	PM44-47	PM48-50	PM51-53	PM54-56
Estimated MTBF hrs	35,000	34,000	29,000	25,000



Graph 4



Graph 5



COMPONENTS FOR PLUG IN PC BOARD ASSY N° 26521				
REF	DESCRIPTION			PART N°
RESISTORS				
R1	82 Ω	ELECTROSIL TR5	5%	15137
R2	54K	ELECTROSIL TR5	5%	15717
R3	1K	ELECTROSIL TR5	5%	19135
R4	60 Ω	ELECTROSIL TR5	5%	19145
R5	2K	ELECTROSIL TR5	5%	18717
R6	11K	ELECTROSIL TR5	5%	19575
R7	56K	ELECTROSIL TR5	5%	18717
R8	12K	ELECTROSIL TR5	5%	19145
R9	470 Ω	ELECTROSIL TR5	5%	18713
R10	800 Ω	ELECTROSIL TR5	5%	19036
R11	510 Ω	ELECTROSIL TR5	5%	19571
R12	40K	ELECTROSIL TR5	5%	19036
R13	33K	ELECTROSIL TR5	5%	18705
R14	560 Ω	C.G.S. TYPE CR1.5	5%	25232
R15	100 Ω	C.G.S. TYPE CR1.5	5%	28566
R16	10T	ELECTROSIL TR5	5%	
R17	47K	ELECTROSIL TR5	5%	18706
R18	33K	ELECTROSIL TR5	5%	18705
R19	67K	ELECTROSIL TR5	5%	18706
R20	67K	ELECTROSIL TR5	5%	18717
R21	1.8K	ELECTROSIL TR5	5%	18700
R22	10T	ELECTROSIL TR5	5%	
R23	10K	ELECTROSIL TR5	5%	18705
R24	10K	ELECTROSIL TR5	5%	18714
R25	39 Ω	ELECTROSIL TR5	5%	19133
R26	LINK			
R27	NOT USED.			
R28	NOT USED.			
R29	NOT USED.			
R30	NOT USED.			
R31	100 Ω	ELECTROSIL TR5	5%	19143
R32	47 Ω	ELECTROSIL TR5	5%	19134
R33	47 Ω	ELECTROSIL TR5	5%	19134
R34	220 Ω	ELECTROSIL TR5	5%	18627
CAPACITORS				
C1	25 μ F	40V C40 AR/GES MULLARD		80083
C2	25 μ F	40V C40 AR/GES MULLARD		80080
C3	3300 μ F	10% 400V C296 AC/A MULLARD		774

REF	DESCRIPTION	CAPACITORS	PART
CAPACITORS (CONT'D)			
C4	25A 25V C428	ALFIB 5 MULLARD	2272
C5	0.01A 60V 400V C28	ALFA MULLARD	781
SEMICONDUCTORS			
MR1	DIODE	AEI	MS14 H
MR2	DIODE	AEI	MS14 H
MR3	ZENER DIODE	9V	2F50
MR4	DIODE	INT RECT	1N201
MR5	ZENER DIODE	37C	2F51
MR6	DIODE	AEI	MS14 H
MR7	DIODE	AEI	MS14 H
MR8	DIODE	AEI	MS14 H
MR9	DIODE	AEI	MS14 H
TRANSISTORS			
VT1	TRANSISTOR	RCA	2N 3053
VT2	TRANSISTOR	MULLARD	BCY 70
VT3	TRANSISTOR	MULLARD	85X 20
VT4	TRANSISTOR	MULLARD	85X 20
VT5	TRANSISTOR	MULLARD	85X 20
VT6	TRANSISTOR	MULLARD	85X 20
VT7	TRANSISTOR	MULLARD	85X 20
VT8	TRANSISTOR	MULLARD	85X 20
VT9	TRANSISTOR	MULLARD	85X 20
VT10	TRANSISTOR	MULLARD	85X 20
COMPONENTS FOR AUXILIARY PCBOARD			
RESISTORS			
R103	SEE SEPARATE TABLE		
R104	ADT ELECTROSIL	75 5%	
R105	ADT ELECTROSIL	75 5%	
R107	SEE SEPARATE TABLE		
R108	NOT USED.		
R110	SEE ADJUST WITH VOLT TABLE		
R111	SEE ADJUST WITH VOLT TABLE		
R112	22A ELECTROSIL	75 5%	
R113	50A ELECTROSIL	75 5%	
R114	27A ELECTROSIL	75 5%	

REF	DESCRIPTION	PART NO
	RESISTORS CONT	
R116	200K ELECTROL TRS 5%	1870B
R117	33K ADJUST WITH VOLTS TABLES	
R118	33K ADJUST WITH VOLTS TABLE	
R119	100K ELECTROL TRS 5%	1870D
	CAPACITORS	
C103	405K 44V C42B ARCAD	20082
C104	52F 44V C42B ARCAD	20094
C108	1000PF 10% CERAMIC	2238
	SEMICONDUCTORS	
MR101	ZENER DIODE 5TC IFB3	4034
VT100	TRANSISTOR 1N 432 B010B	2010
COMPONENTS FOR ONER VOLTAGE REBOARD		
	RESISTORS	
R50	33K ADJUST WITH VOLTS TABLE	
R51	5K ELECTROL TRS 5%	183AA
R52	5K ELECTROL TRS 5%	1870B
R53	33K ELECTROL TRS 5%	183B
R54	52K SEMI-KAL TABLE	
R55	15K ELECTROL TRS 5%	1870B
R56	1K ELECTROL TRS 5%	1933B
R57	33K ADJUST WITH VOLTS TABLE	
	DIODE - DIETER	
RV50	33K 0% RESSEY M P D	4425
	SEMICONDUCTORS	
MR50	ZENER DIODE 5TC IFSW	4109
MR51	ZENER DIODE HUGHES 457087	21002
VT50	TRANSISTOR TEXAS 25-45 A	2083/
VT51	TRANSISTOR TEXAS 85-45 A	2085/
VT52	TRANSISTOR (SEE NOTE BELOW)	
NOTE - VT 52 TRANSISTOR		
0-30V	ALL UNITS USE BAX 88	22337
30-50V	UNITS ONLY USE BAX 29	50281

PM 44				PM 45				PM 46				PM 47				PM 48				PM 49				PM 50			
REF	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No
TI	TRANSFORMER	1	MT527	TRANSFORMER	1	MT624	TRANSFORMER	1	MT529	TRANSFORMER	1	MT584	TRANSFORMER	1	MT624	TRANSFORMER	1	MT532	TRANSFORMER	1	MT583	TRANSFORMER	1	MT583	TRANSFORMER	1	MT583
CAPACITORS				CAPACITORS				CAPACITORS				CAPACITORS				CAPACITORS				CAPACITORS				CAPACITORS			
C100	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804
C101	SPRAGUE 36D182G040AA2A (1800 μ F 40V)	1	22710	SPRAGUE 36D85F075AA2A (500 μ F 75V)	1	22716	SPRAGUE 36D90F100AB2A (900 μ F 100V)	1	22719	SPRAGUE 36D42G040AD2A (6400 μ F 40V)	1	22708	SPRAGUE 36D392F075BB2A (3900 μ F 75V)	1	22714	SPRAGUE 36D302F100BC2A (3000 μ F 100V)	1	22718	SPRAGUE 36D123G04BC2A (1200 μ F 40V)	1	22501	SPRAGUE 36D123G04BC2A (1200 μ F 40V)	1	22501	SPRAGUE 36D123G04BC2A (1200 μ F 40V)	1	22501
C102	MULLARD C431 BR/G500 (500 μ F 40V)	1	3102	MULLARD C431 BR/G500 (500 μ F 40V)	1	3102	MULLARD C431 BR/H500 (500 μ F 64V)	1	18780	MULLARD C431 BR/F250 (1250 μ F 25V)	1	19215	MULLARD C431 BR/G800 (800 μ F 40V)	1	2799	MULLARD C431 BR/H800 (800 μ F 64V)	1	18147	MULLARD C431 BR/F2000 (2000 μ F 25V)	1	4847	MULLARD C431 BR/F2000 (2000 μ F 25V)	1	4847	MULLARD C431 BR/F2000 (2000 μ F 25V)	1	4847
RESISTORS				RESISTORS				RESISTORS				RESISTORS				RESISTORS				RESISTORS				RESISTORS			
R100	ELECTROSIL TR5 (27K 5%)	1	18771	ELECTROSIL TR5 (47K 5%)	1	18706	CGS VPF-4 (68K 5%)	1	2053	CGS VPF-10 (80 5%)	1	19642	CGS VPF-10 (15K 5%)	1	4806	CGS VPF-10 (2.2K)	1	17745	CGS VPF-10 (270 5%)	1	19641	CGS VPF-10 (270 5%)	1	19641	CGS VPF-10 (270 5%)	1	19641
R101	CGS VPF-10 (1 5% 10W)	1	23066	CGS VPF-10 (1 5%)	1	23066	CGS VPF-10 (1 5%)	1	23066	CGS VPF-10 (0.33 5%)	1	24969	CGS VPF-10 (0.68 5%)	2	23067	CGS VPF-10 (0.68 5%)	2	23067	CGS VPF-10 (0.39 5%)	2	25142	CGS VPF-10 (0.39 5%)	2	25142	CGS VPF-10 (0.39 5%)	2	25142
R102	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	2	18702	ELECTROSIL TR5 (100 5%)	2	18702	ELECTROSIL TR5 (100 5%)	2	18702	ELECTROSIL TR5 (100 5%)	2	18702
TRANSISTORS				TRANSISTORS				TRANSISTORS				TRANSISTORS				TRANSISTORS				TRANSISTORS				TRANSISTORS			
VT100	RCA 40250	1	4224	RCA 40250	1	4224	SDT 9202	1	24385	RCA 2N3055	1	3813	RCA 40250	1	4224	SDT 9202	1	24385	RCA 40250	1	4224	RCA 40250	1	4224	RCA 40250	1	4224
VT101	RCA 2N3055	1	3813	RCA 2N3055	1	3813	SDT 9202	1	24385	RCA 2N3055	1	3813	RCA 2N3055	2	3813	SDT 9202	2	24385	RCA 2N3055	2	3813	RCA 2N3055	2	3813	RCA 2N3055	2	3813
MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS			
MR100	RECTIFIER W005 PIRELLI 50V	1	19724	RECTIFIER W02 PIRELLI 200V	1	19725	RECTIFIER W02 PIRELLI 200V	1	19725	RECTIFIER TEXAS IB40K20 200V	1	17763	RECTIFIER TEXAS IB40K20 200V	1	17763	RECTIFIER TEXAS IB40K20 200V	1	17763	RECTIFIER TEXAS IB40K20 200V	1	17763	RECTIFIER SEMTECH SCBA2 200V	1	22721	RECTIFIER SEMTECH SCBA2 200V	1	22721
RV100	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272	CONTROL POT COLVERN 1106/95 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/95 220 10%	1	26273	CONTROL POT COLVERN 1106/95 330 10%	1	26758	CONTROL POT COLVERN 1106/95 330 10%	1	26758	CONTROL POT COLVERN 1106/95 220 10%	1	26273	CONTROL POT COLVERN 1106/95 220 10%	1	26273	CONTROL POT COLVERN 1106/95 330 10%	1	26758	CONTROL POT COLVERN 1106/95 330 10%	1	26758	CONTROL POT COLVERN 1106/95 220 10%	1	26273	CONTROL POT COLVERN 1106/95 220 10%	1	26273
FS1	FUSE B/LEE L562 (240V 1A)	1	1254	FUSE B/LEE L562 (240V 2.5A)	1	21189	FUSE B/LEE L562 (240V 2.5A)	1	21189	FUSE B/LEE L562 (240V 2.5A)	1	21189	FUSE B/LEE L693 (240V 3A)	1	12699	FUSE B/LEE L693 (240V 5A)	1	638	FUSE B/LEE L693 (240V 3A)	1	12699	FUSE B/LEE L693 (240V 3A)	1	12699	FUSE B/LEE L693 (240V 3A)	1	12699
FS2	FUSE B/LEE L562 (2.5A)	1	21189	FUSE B/LEE L562 (2.5A)	1	21189	FUSE B/LEE L562 (2.5A)	1	21189	FUSE B/LEE L562 (4A)	1	5120	FUSE B/LEE L693 (5A)	1	638	FUSE B/LEE L693 (7A)	1	13040	FUSE B/LEE L693 (7A)	1	13040	FUSE B/LEE L693 (7A)	1	13040	FUSE B/LEE L693 (7A)	1	13040
MR101	THYRISTOR BTY 79/100R	1	18693	THYRISTOR BTY 79/100R	1	18693	THYRISTOR BTY 79/100R	1	18693	THYRISTOR BTY 87/100R	1	23074	THYRISTOR BTY 87/100R	1	23074	THYRISTOR BTY 87/100R	1	23074	THYRISTOR BTY 87/100R	1	23074	THYRISTOR BTY 87/100R	1	23074	THYRISTOR BTY 87/100R	1	23074

PM 51				PM 52				PM 53				PM 54				PM 55				PM 56			
REF	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No	DESCRIPTION	QTY	PART No		
TI	TRANSFORMER	1	MT626	TRANSFORMER	1	MT535	TRANSFORMER	1	MT582	TRANSFORMER	1	MT627	TRANSFORMER	1	MT538	TRANSFORMER	1	MT618	TRANSFORMER	1	MT618		
CAPACITORS				CAPACITORS				CAPACITORS				CAPACITORS				CAPACITORS				CAPACITORS			
C100	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	804	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	807	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	807	MULLARD C296 AA/A (0.1 μ F 10% 160V)	1	807	MULLARD C296 AA/A (0.1 μ F 10% 160V)	2	807		
C101	SPRAGUE 36D692F075BD2A (7500 μ F 75V)	1	22712	SPRAGUE 36D532F100CC2A (15300 μ F 100V)	1	22717	SPRAGUE 36D123G040BC2A (1200 μ F 40V)	2	22501	SPRAGUE 36D692F075BD2A (7500 μ F 75V)	1	22712	SPRAGUE 36D532F100CC2A (15300 μ F 100V)	2	22717	SPRAGUE 36D13G040BC2A (12000 μ F 40V)	4	22501	SPRAGUE 36D13G040BC2A (12000 μ F 40V)	4	22501		
C102	MULLARD C431 BR/G2500 (2500 μ F 40V)	1	4848	MULLARD C431 BR/H2500 (2500 μ F 64V)	1	4849	MULLARD C431 BR/F4000 (4000 μ F 25V)	1	4850	MULLARD C431 BR/G4000 (4000 μ F 40V)	1	4851	MULLARD C431 BR/H2500 (2500 μ F 64V)	2	4849	SPRAGUE 36D22G025AC2A (8200 μ F 25V)	1	25251	SPRAGUE 36D22G025AC2A (8200 μ F 25V)	1	25251		
OR HUGHES 6200 μ F 75V FOR C101				OR HUGHES 6200 μ F 75V FOR C101				OR HUGHES 6200 μ F 75V FOR C101				OR HUGHES 6200 μ F 75V FOR C101				OR HUGHES 6200 μ F 75V FOR C101				OR HUGHES 6200 μ F 75V FOR C101			
RESISTORS				RESISTORS				RESISTORS				RESISTORS				RESISTORS				RESISTORS			
R100	CGS VPF-10 (470 5%)	1	4805	CGS VPF-10 (1.5K 5%)	1	4806	CGS VPF-10 (270 5%)	1	19641	CGS VPF-14 (470 5%)	1	19363	CGS VPF-14 (1K)	2	18755	CGS VPF-14 (270 5%)	2	18767	CGS VPF-14 (270 5%)	2	18767		
R101	CGS VPF-10 (0.82 5%)	4	25143	CGS VPF-10 (1 5%)	5	23066	CGS VPF-10 (0.39 5%)	4	25142	CGS VPF-10 (0.68 5%)	7	23067	CGS VPF-10 (1)	10	23066	CGS VPF-10 (0.47 5%)	9	23069	CGS VPF-10 (0.47 5%)	9	23069		
R102	ELECTROSIL TR5 (22 5%)	4	18707	ELECTROSIL TR5 (27 5%)	5	1913	ELECTROSIL TR5 (22 5%)	4	18707	ELECTROSIL TR5 (33 5%)	7	19132	ELECTROSIL TR5 (51 5%)	10	19562	ELECTROSIL TR5 (47 5%)	9	19134	ELECTROSIL TR5 (47 5%)	9	19134		
R106	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702		
R109	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702	ELECTROSIL TR5 (100 5%)	1	18702		
R115	ELECTROSIL TR5 (100 5%)	4	18702	ELECTROSIL TR5 (100 5%)	5	18702	ELECTROSIL TR5 (100 5%)	4	18702	ELECTROSIL TR5 (100 5%)	7	18702	ELECTROSIL TR5 (100 5%)	10	18702	ELECTROSIL TR5 (100 5%)	9	18702	ELECTROSIL TR5 (100 5%)	9	18702		
TRANSISTORS				TRANSISTORS				TRANSISTORS				TRANSISTORS				TRANSISTORS				TRANSISTORS			
VT100	RCA 2N3055	1	3813	SDT 9202	1	24385	RCA 2N3055	1	3813	RCA 2N3055	1	3813	RCA 2N3055	1	24385	RCA 2N3055	1	3813	RCA 2N3055	1	3813		
VT101	RCA 2N3055	4	3813	SDT 9202	5	24385	RCA 2N3055	4	3813	RCA 2N3055	7	3813	RCA 2N3055	10	24385	RCA 2N3055	9	3813	RCA 2N3055	9	3813		
MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS				MISCELLANEOUS			
MR100	RECTIFIER SEMTECH SCBA2 (200V)	1	22721	RECTIFIER SEMTECH SCBA2 (200V)	1	22721	RECTIFIER SEMTECH SCBA2 (200V)	1	22721	RECTIFIER LUCAS DIODES DD6123 200V	2	27214	RECTIFIER LUCAS DIODES DD6123 200V	2	27214	RECTIFIER LUCAS DIODES DD6123 200V	2	27214	RECTIFIER LUCAS DIODES DD6123 200V	2	27214		
										RECTIFIER LUCAS DIODES DD6123A 200V	2	27215	RECTIFIER LUCAS DIODES DD6123A 200V	2	27215	RECTIFIER LUCAS DIODES DD6123A 200V	2	27215	RECTIFIER LUCAS DIODES DD6123A 200V	2	27215		
RV100	CONTROL POT COLVERN 1106/95 (120 10%)	1	26272	CONTROL POT COLVERN 1106/95 (120 10%)	1	26272	CONTROL POT COLVERN 1106/95 (120 10%)	1	26272	CONTROL POT COLVERN 1106/95 (120 10%)	1	26272	CONTROL POT COLVERN 1106/95 (120 10%)	1	26272	CONTROL POT COLVERN 1106/95 (120 10%)	1	26272	CONTROL POT COLVERN 1106/95 (120 10%)	1	26272		
RV101	CONTROL POT COLVERN 1106/95 (330 10%)	1	26758	CONTROL POT COLVERN 1106/95 (330 10%)	1	26758	CONTROL POT COLVERN 1106/95 (220 10%)	1	26273	CONTROL POT COLVERN 1106/95 (330 10%)	1	26758	CONTROL POT COLVERN 1106/95 (330 10%)	1	26758	CONTROL POT COLVERN 1106/95 (220 10%)	1	26273	CONTROL POT COLVERN 1106/95 (220 10%)	1	26273		
FUSE B/LEE L693 (240V 5A)				FUSE B/LEE L693 (240V 7A)				FUSE B/LEE L693 (240V 5A)				FUSE B/LEE L693 (240V 7A)				FUSE B/LEE L693 (240V 10A)				FUSE B/LEE L693 (240V 10A)			
F52	FUSE B/LEE L693 (7A)	1	13040	FUSE B/LEE L693 (7A)	1	13040	FUSE B/LEE L1055 (12A)	1	20834	FUSE B/LEE L1055 (12A)	1	20834	FUSE B/LEE L1055 (12A)	1	4227	FUSE B/LEE L693 (240V 10A)	1	4227	FUSE AEI GS150/25 (25A)	1	19021		
MR101	THYRISTOR BTY871100R	1	25474	THYRISTOR BTY871100R	1	25474	THYRISTOR 2N3896	1	25473	THYRISTOR 2N3896	1	25473	THYRISTOR 2N3896	1	25473	THYRISTOR AEI CR-26-051 BI	1	27298	THYRISTOR AEI CR-26-051 BI	1	27298		

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than tubes, semiconductors and fuses. Tubes and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The Type and Serial Number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with the transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

**OUR SALES, SERVICE AND ENGINEERING DEPARTMENTS
ARE READY TO ASSIST YOU AT ALL TIMES.**



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